

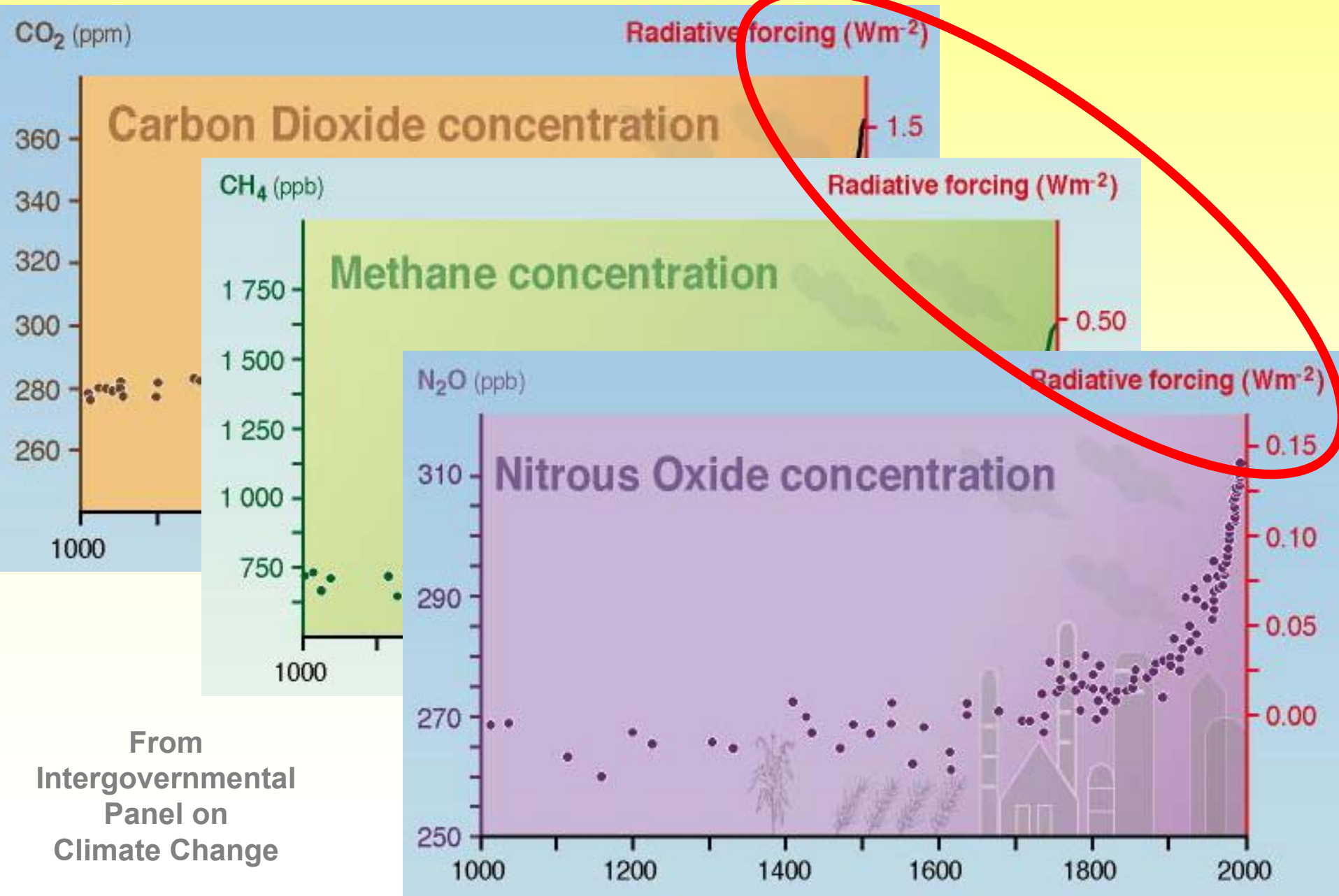
Soil Carbon Sequestration from Conservation Agricultural Systems in Georgia

Alan J.
Franzluebbers
Ecologist

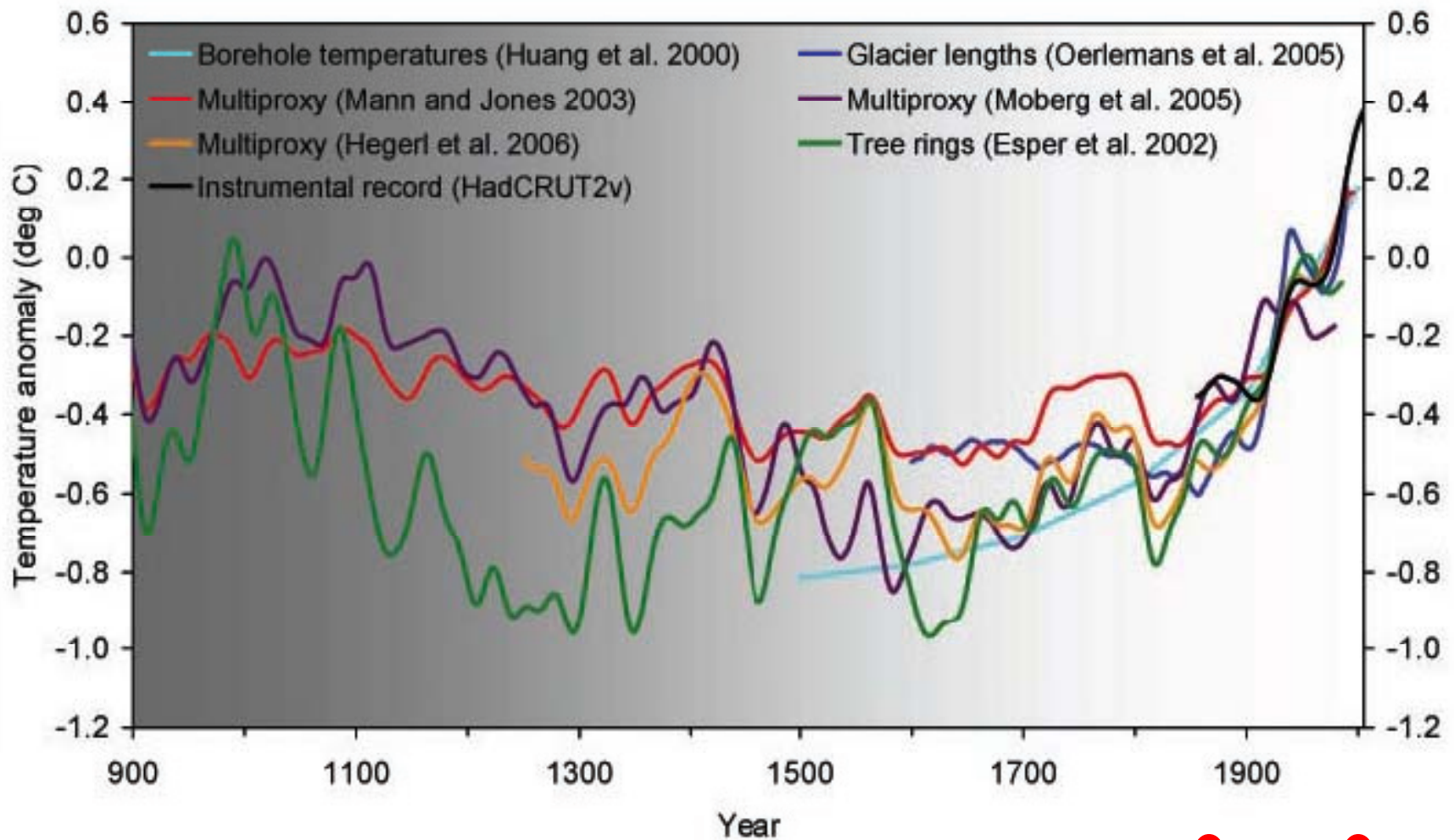
Watkinsville GA



Global Concern is in the Air

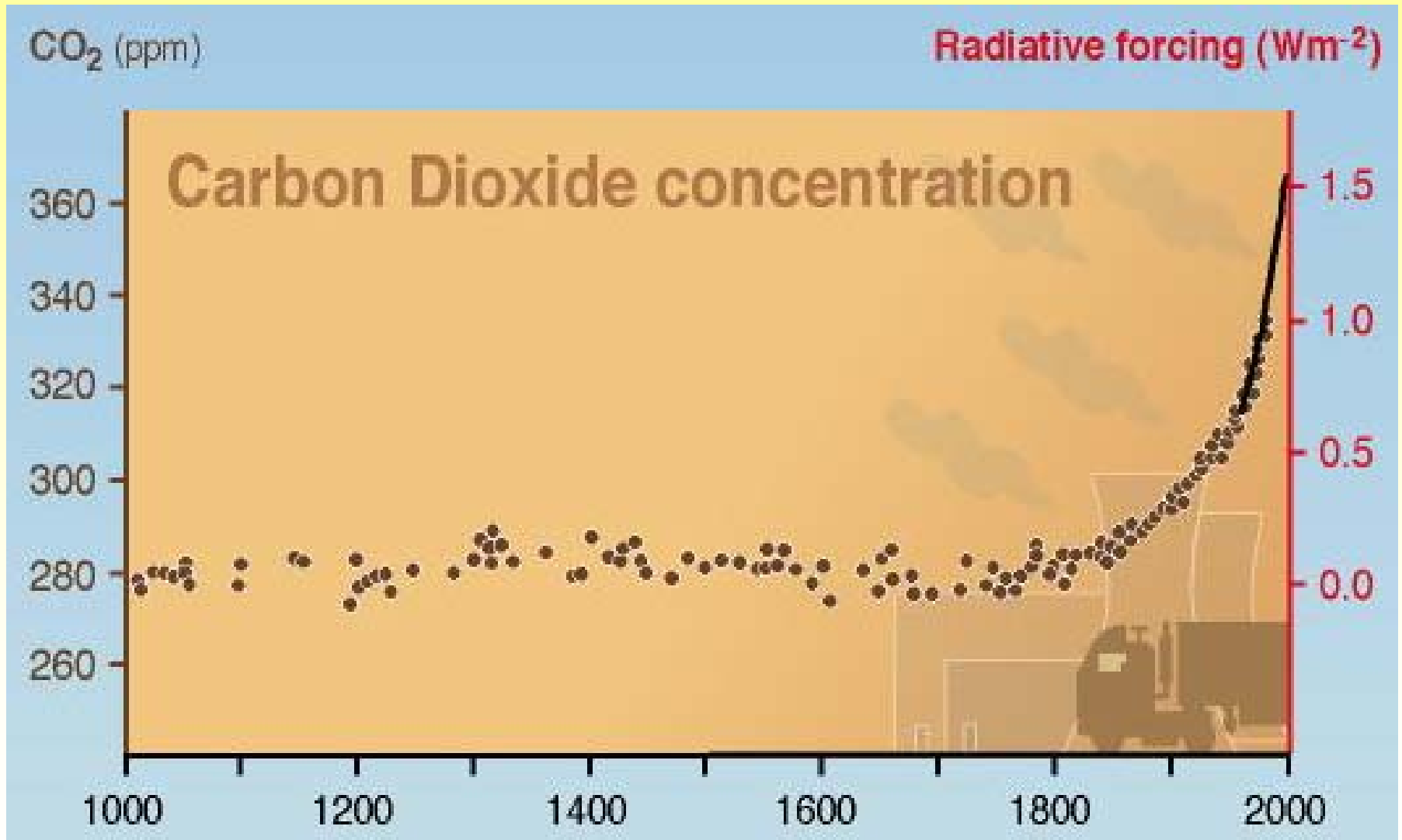


Climate Change Debate



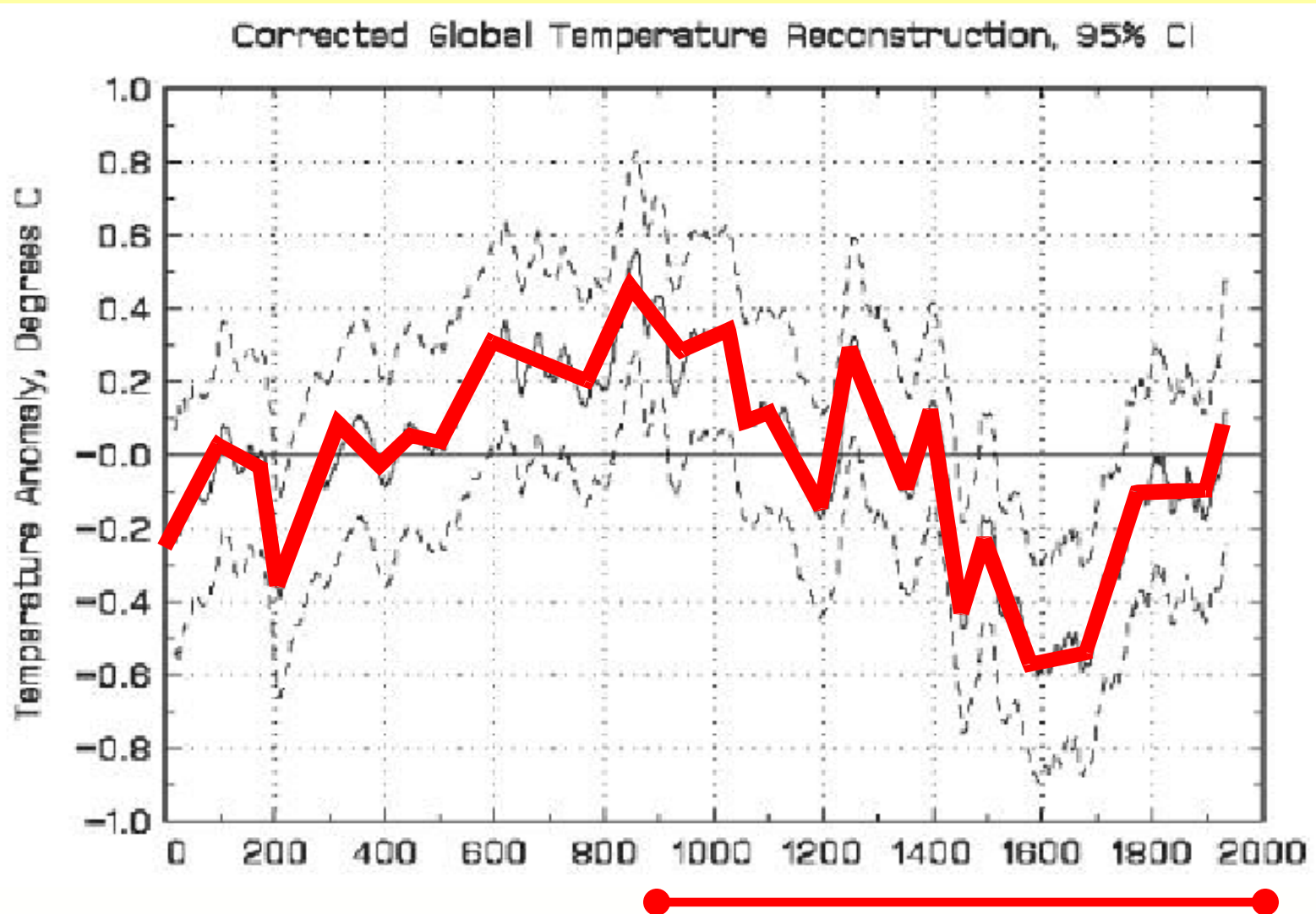
Mary Cleave – NASA (personal communication)

Climate Change Debate



From Intergovernmental Panel on Climate Change

Climate Change Debate

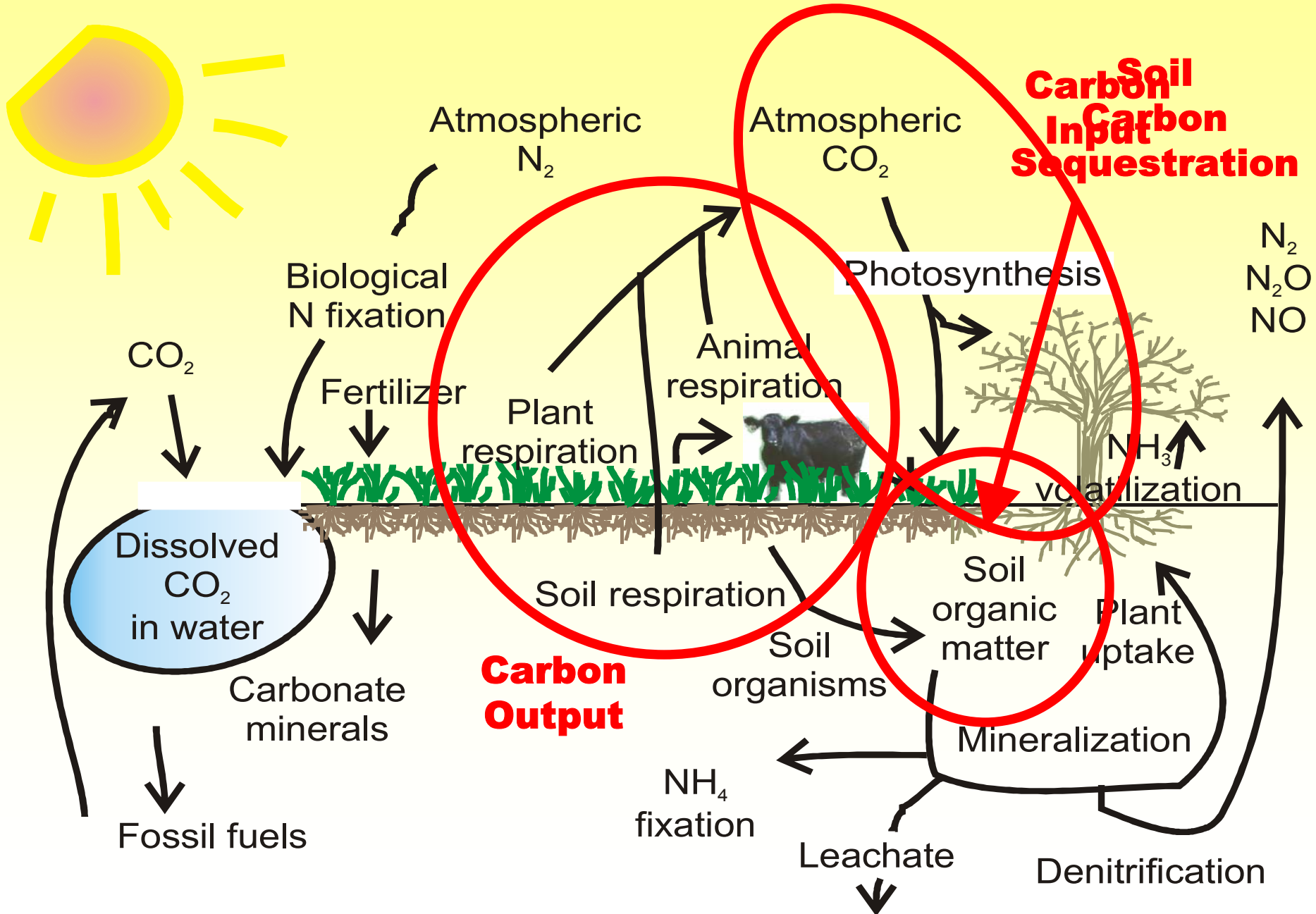


Loehle and McCulloch (2008) Energy and Environment 19:93-100

Managing Carbon Emission

- ✓ **Rising concentration of greenhouse gases has been largely attributed to expanding use of fossil fuels as an energy source, resulting in emission of CO₂ to the atmosphere**
- ✓ **Reducing net greenhouse gas emission is possible:**
 - 1. Reduce fossil fuel combustion by becoming more energy efficient**
 - 2. Rely more on low-carbon energy sources**
 - Solar energy capture
 - Wind power generation
 - Biomass fuels
 - 3. Carbon sequestration**

Terrestrial Carbon Sequestration



Management Approaches to Sequester Soil Carbon from Atmosphere to Biosphere

Focus on maximizing carbon input 

■ Plant selection

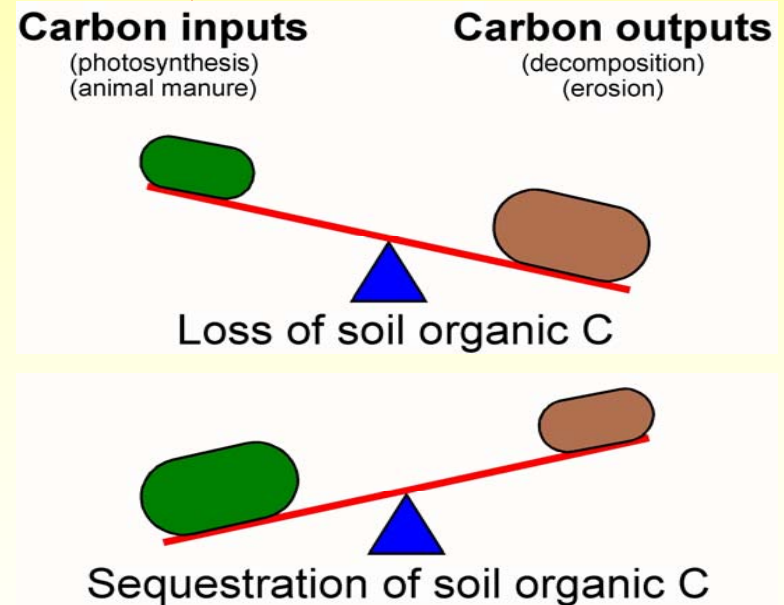
- Species, cultivar, variety
- Growth habit (perennial / annual)
- Rotation sequence
- Biomass energy crops

■ Tillage

- Type
- Frequency

■ Fertilization

- Rate, timing, placement
- Organic amendments



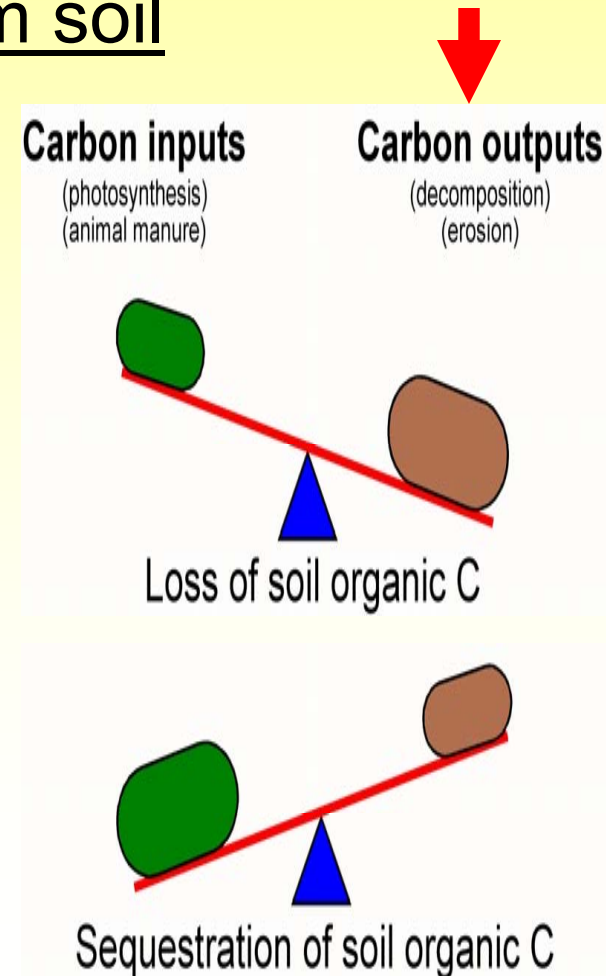
■ Integrated management

- Pest control
- Crop / livestock systems

Management Approaches to Sequester Soil Carbon from Atmosphere to Biosphere

Focus on minimizing carbon loss from soil

- **Reducing soil disturbance**
 - Less intensive tillage
 - Controlling erosion
- **Utilizing available soil water**
 - Promotes optimum plant growth
 - Reduces soil microbial activity
- **Maintaining surface residue cover**
 - Increased plant water use and production
 - More fungal dominance in soil



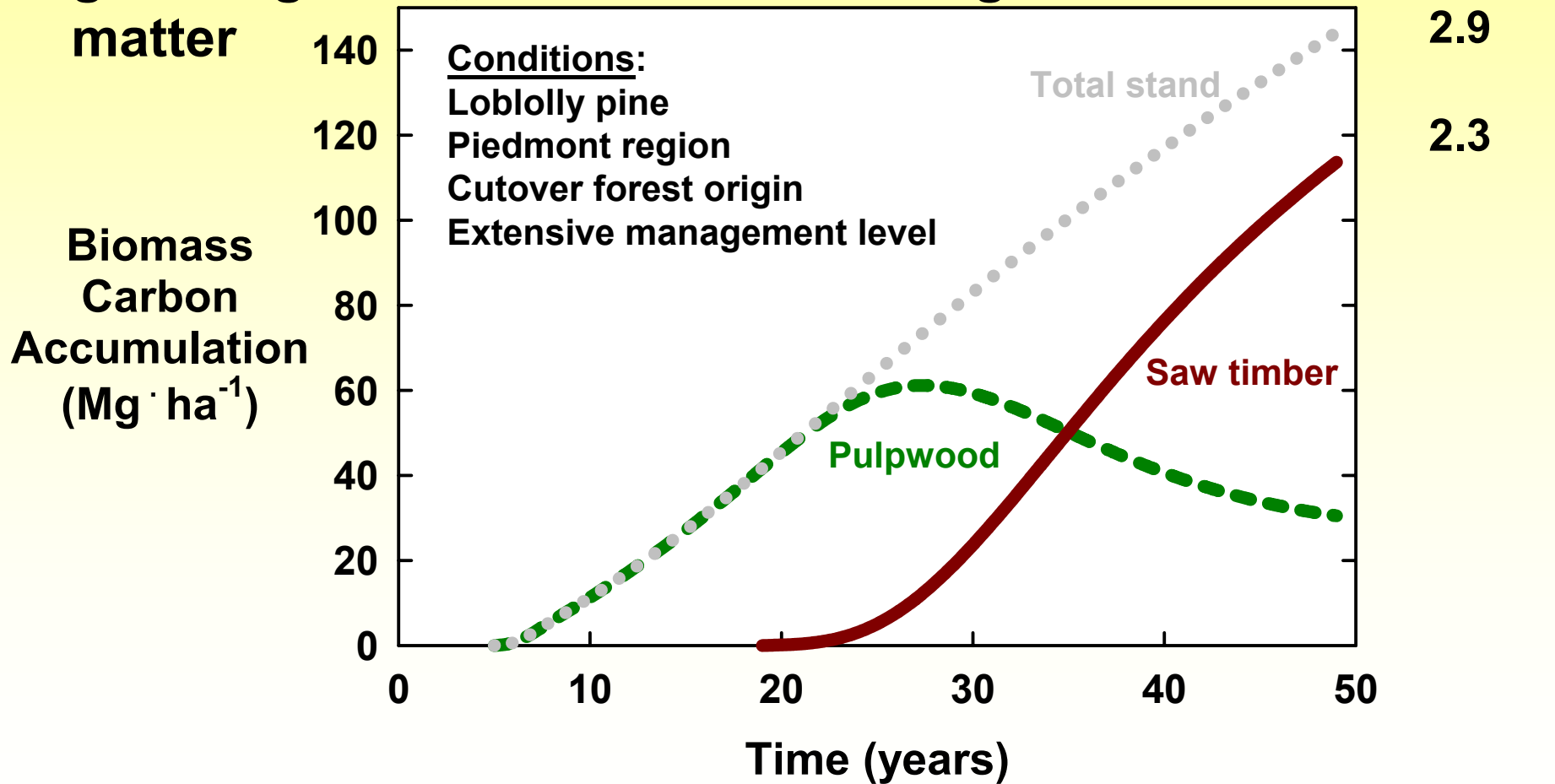
Management Practices to Sequester Carbon and Counter Land Degradation

- ✓ **Tree plantings**
- ✓ **Conservation-tillage cropping**
- ✓ **Animal manure application**
- ✓ **Improved grassland management**
- ✓ **Optimal fertilization**



Tree Plantings

Advantage of accumulating carbon in perennial biomass is in above- and below-ground growth, as well as in soil organic matter



Data from Georgia Forestry Commission (www.gacarbon.org/downloads.aspx)

Tree Plantings

Coarse-root biomass is 20% of total above ground biomass

Markewitz (2007) Georgia Carbon Sequestration Registry

Soil organic C accumulation with tree plantings was estimated at 0.12 ± 0.11 Mg C/ha/yr

Post and Kwon (2000) Global Change Biol. 6:317-327



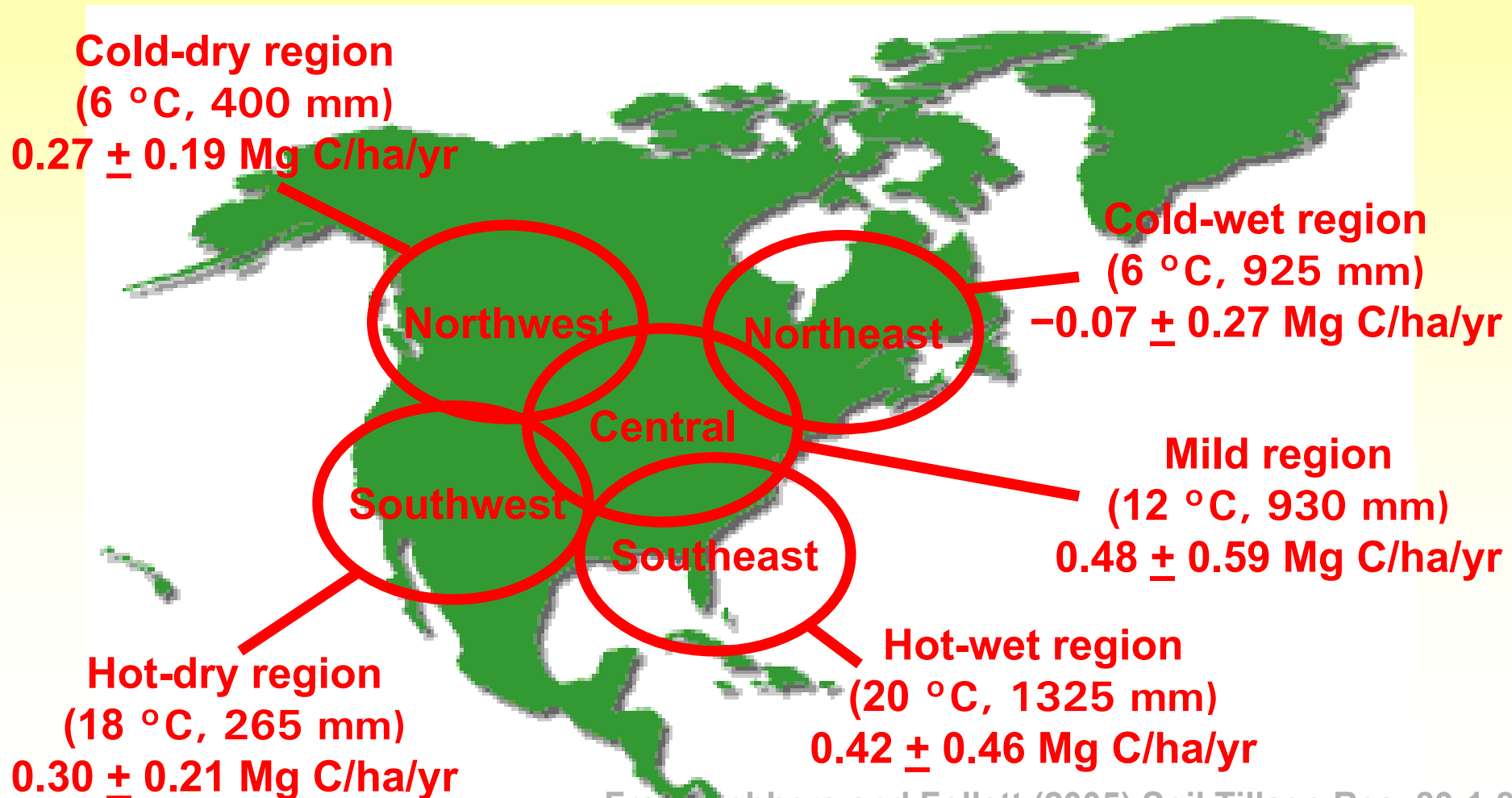
Conservation Tillage

Minimal disturbance of the soil surface is critical in avoiding soil organic matter loss from erosion and microbial decomposition



Conservation Tillage

In the USA and Canada, no-tillage cropping can sequester an average of 0.33 Mg C/ha/yr



Conservation Tillage

No tillage needs high-residue producing cropping system to be effective (i.e. cover cropping, etc.)



Photos of 2 no-tillage systems in Virginia



Soil Organic Carbon Sequestration in the Southeastern USA

**0.28 ± 0.44 Mg C/ha/yr
(without cover cropping)**

**0.53 ± 0.45 Mg C/ha/yr
(with cover cropping)**

Conservation Tillage

Some specific examples of research around Georgia

Athens – UGA
(Horseshoe Bend)

Sorghum / rye cropping
CT and NT established in 1978

Years	Depth (cm)	Δ SOC (NT-CT) (Mg/ha/yr)	Reference
2	15	1.81	Hu et al 1997
5	21	0.40	Groffman 1984
13	15	0.36	Beare et al 1994
13	21	0.26	Hu et al 1995
14	15	0.30	Hu et al 1997
16	21	0.28	Hendrix et al 1998

Conservation Tillage

Some specific examples of research around Georgia

Fort Valley State

Tomato cropping
CT and NT established in 1994
Evaluation at the end of 5 yr
Hairy vetch cover crop

Cover cropping	Δ SOC (NT-CT) (Mg/ha/yr)	Reference
No	0.01	Sainju et al 2002
Yes	0.69	Sainju et al 2002

Conservation Tillage

Some specific examples of research around Georgia

Tifton
Gibbs Farm

Cotton/rye – peanut/rye cropping
Runoff plots established in 1999

Tillage	Soil organic C (0-2 cm depth) (g/kg)
Conventional	7.7 ± 1.0
Strip tillage	12.4 ± 3.4

Potter et al. (2008) J. Environ. Qual. 37:839-847

Other results from study

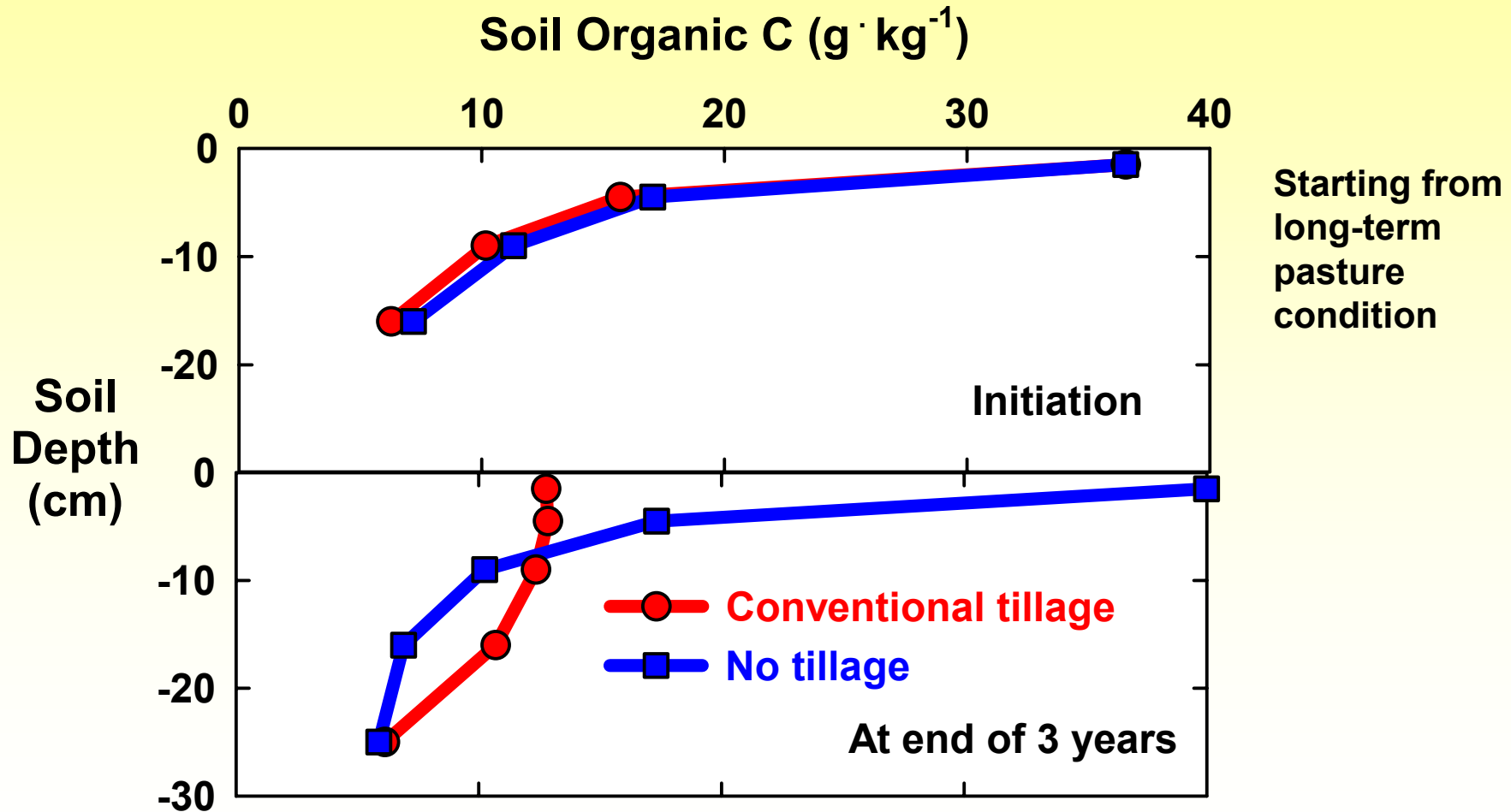
Water runoff (Strip Till < Conv Till)

Infiltration (Strip Till > Conv Till)

Bosch et al. (2005) Trans. ASAE 48:2137-2144

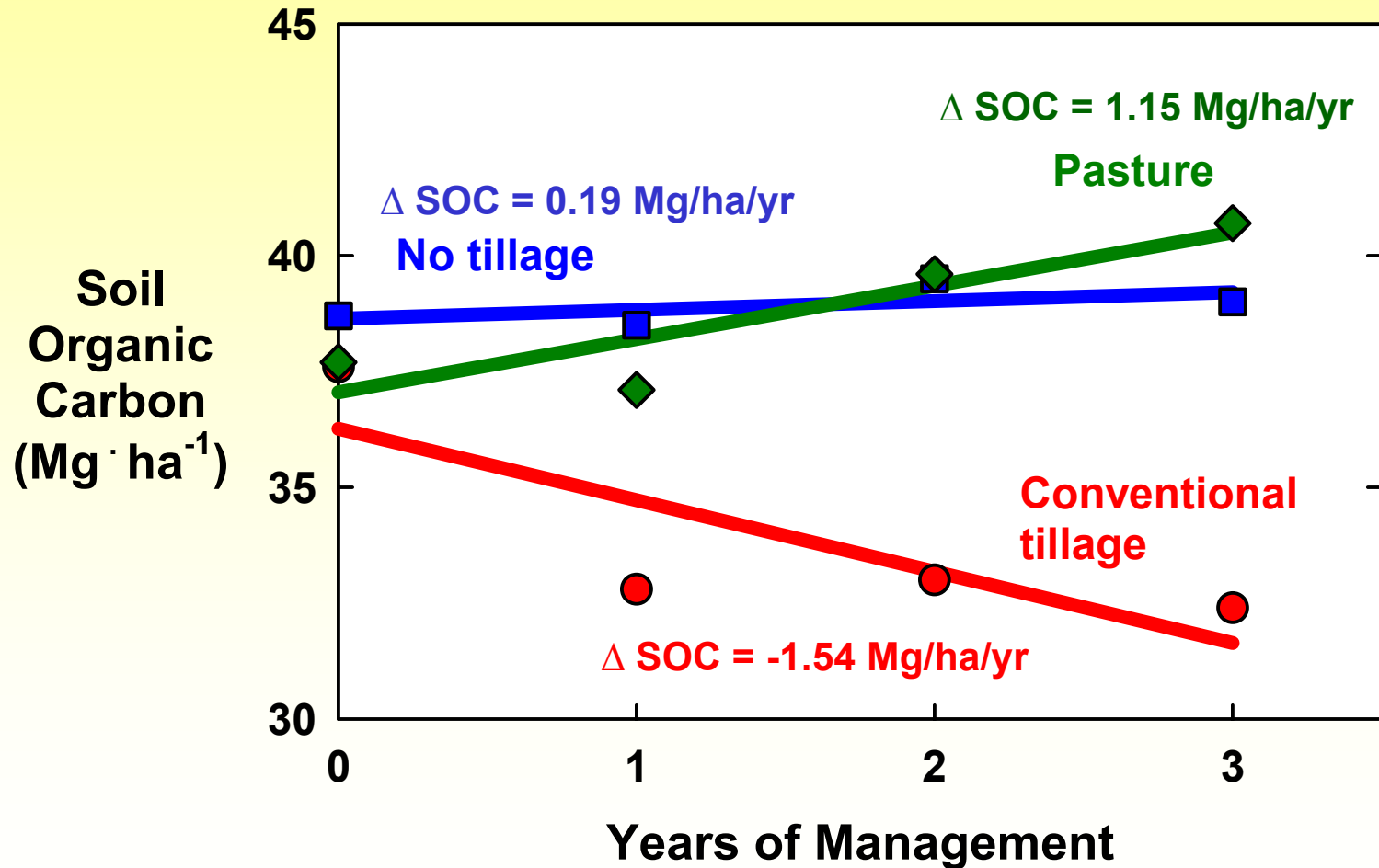
Conservation Tillage

Watkinsville (USDA-ARS)



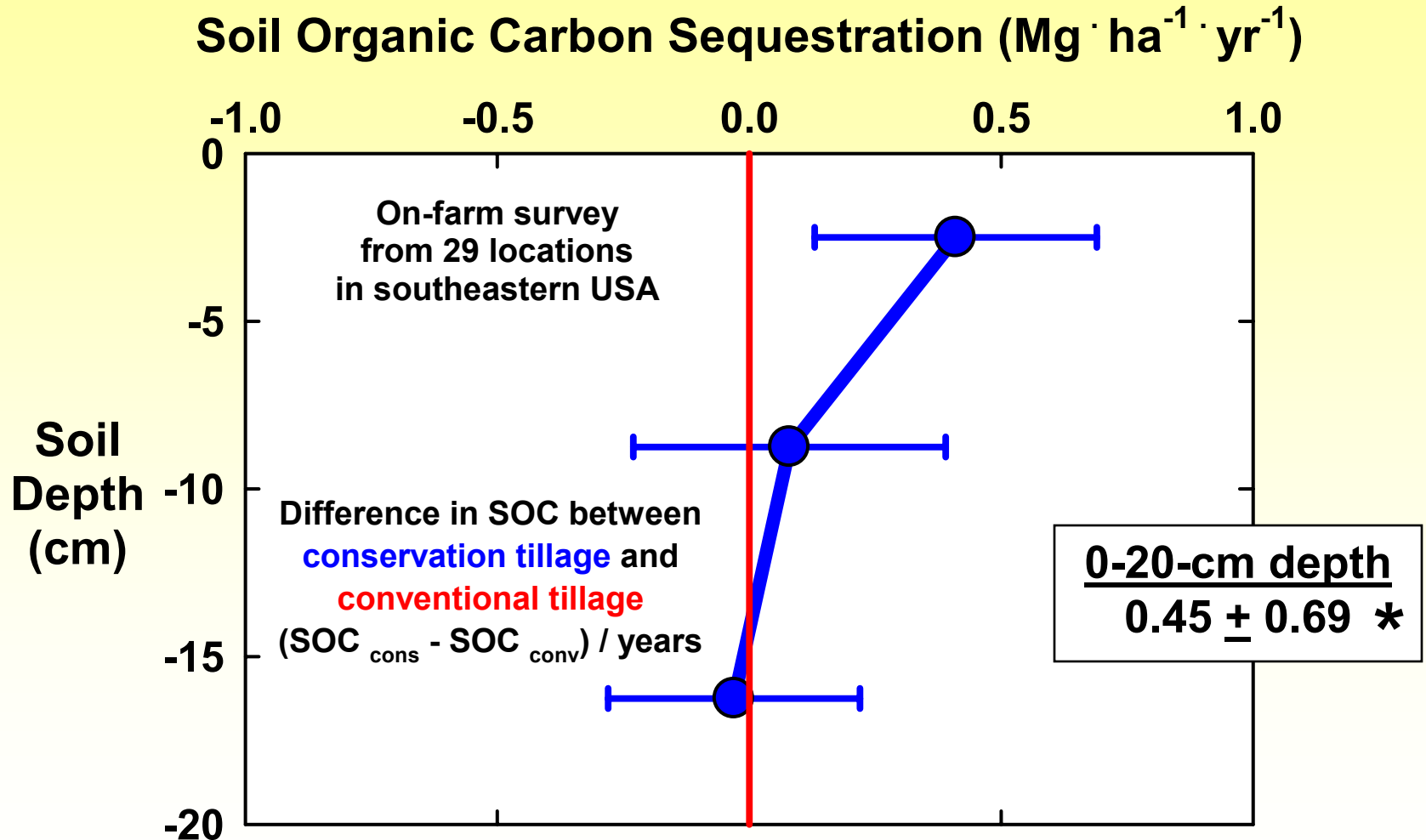
Conservation Tillage

Watkinsville (USDA-ARS)



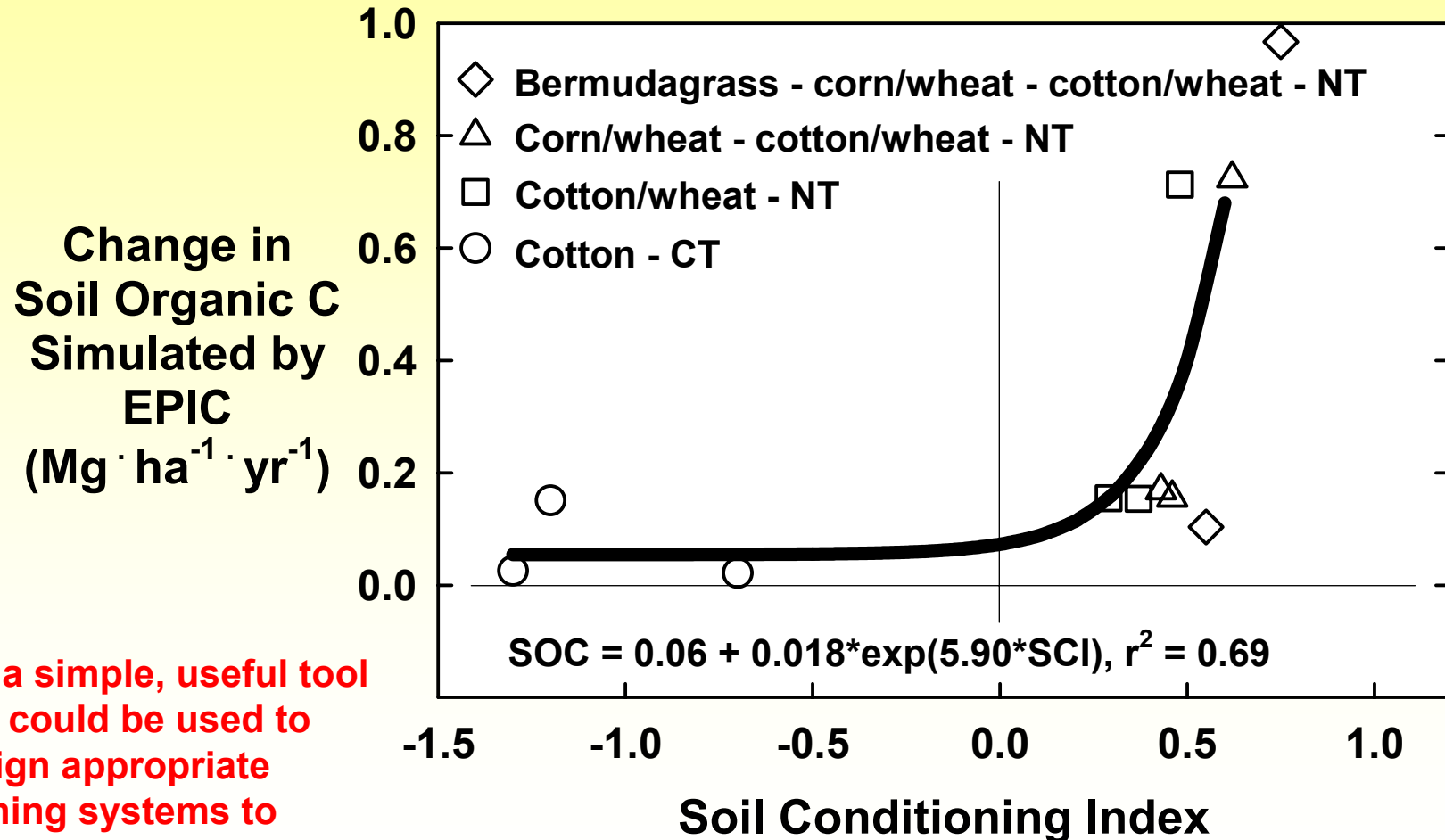
Conservation Tillage

Regional on-farm survey



Conservation Tillage

Modeling of regional farming systems



SCI a simple, useful tool that could be used to design appropriate farming systems to maximize C sequestration in Georgia

Animal Manure Application

Since animal manure contains 40-60% carbon, its application to land should promote soil organic C sequestration

In a 12-year experiment on bermudagrass / tall fescue, soil organic C sequestration due to poultry litter application was 0.24 ± 0.47 Mg C/ha/yr



Conversion of C in poultry litter to soil organic C was $10 \pm 19\%$

Note: Manure application transfers C from one land to another

**Franzluebbers (2005) Soil Tillage Res. 83:120-147
Franzluebbers (unpublished data)**

Improved Grassland Management

- ✓ **Degradation of permanent grasslands can occur from accelerated soil erosion, compaction, drought, and salinization**
- ✓ **Strategies to sequester carbon in soil should improve quality of grasslands**
- ✓ **Strategies for restoration should include:**
 - **Enhancing soil cover**
 - **Planting species with high forage quality and vigorous regrowth potential**
 - **Improving soil structure to minimize water runoff and soil erosion**
 - **Stocking appropriately to utilize forage, but maintain cover**



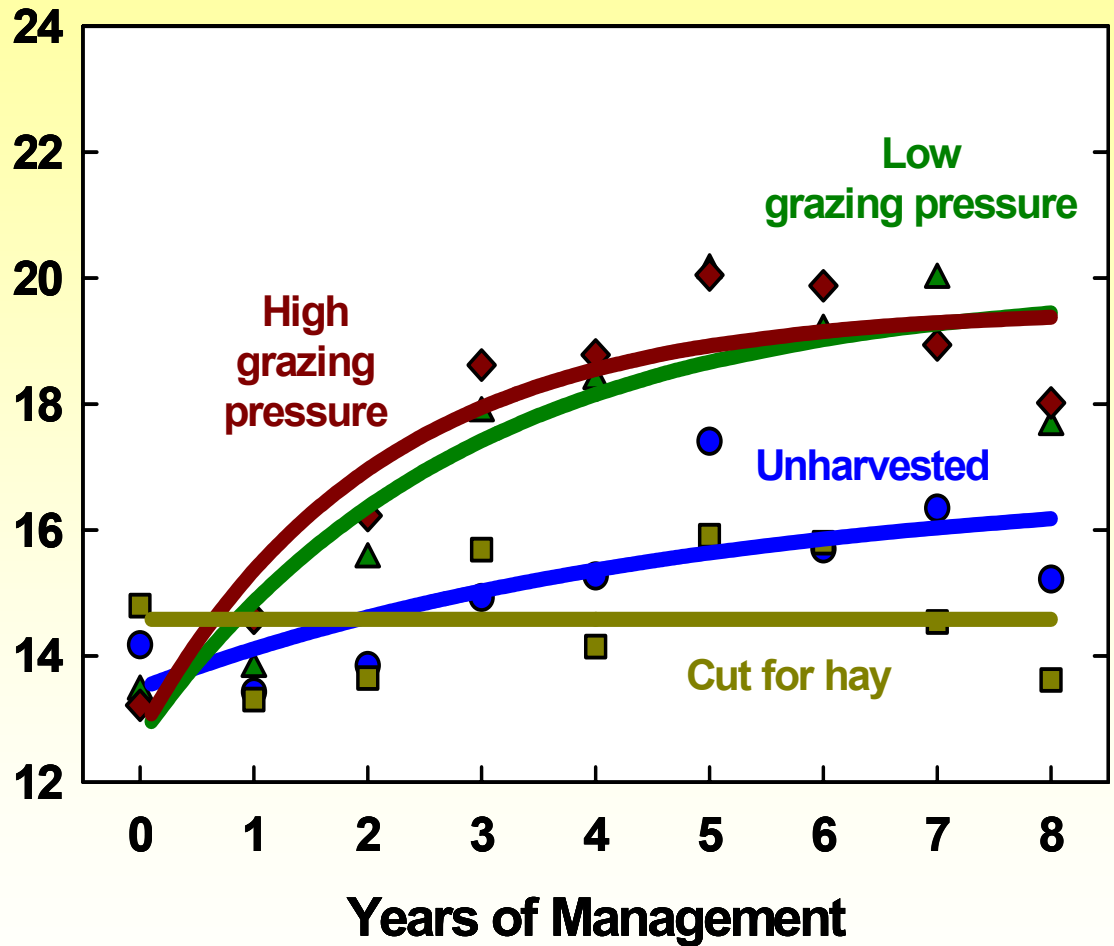
Improved Grassland Management

Establishment of
bermudagrass
pasture following
long-term
cropping in
Watkinsville

Soil
Organic
Carbon
(Mg · ha⁻¹)

Soil organic carbon
sequestration rate
(Mg ha⁻¹ yr⁻¹) (0-5 yr):

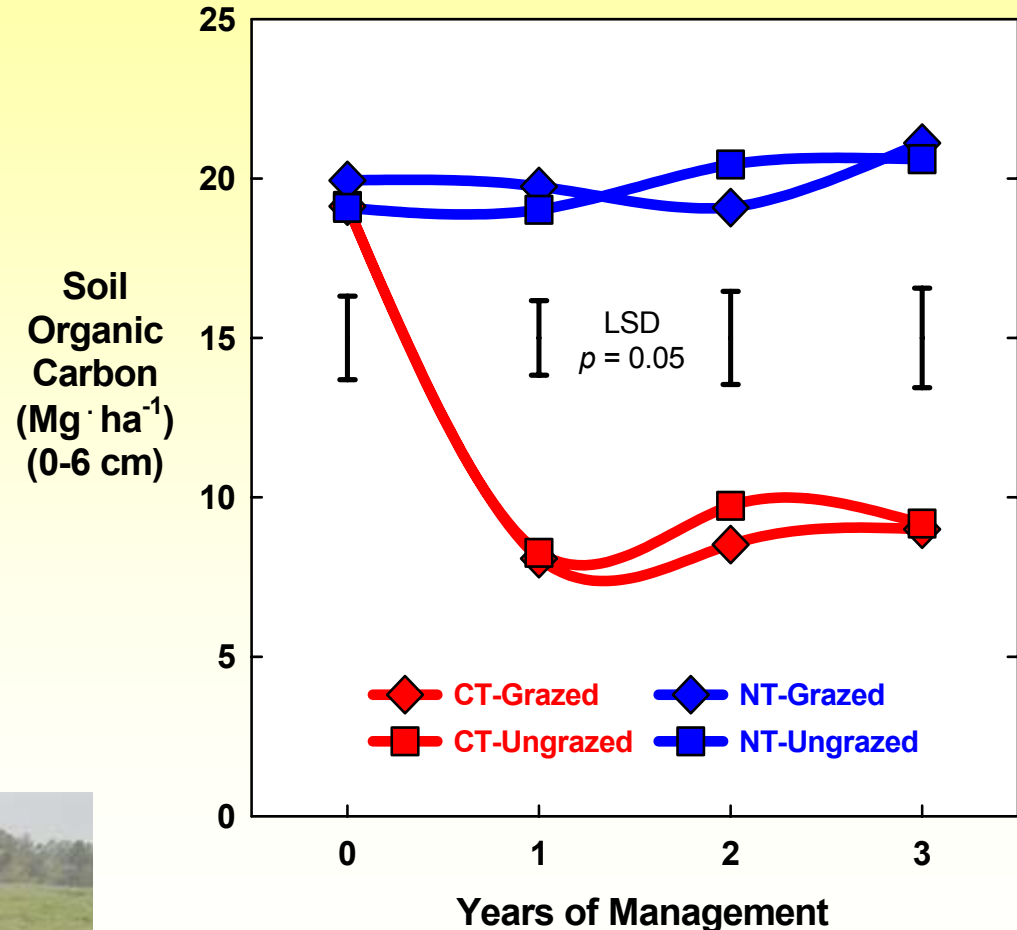
Hayed	0.30
Unharvested	0.65
Grazed	1.40



Cropland-Grazingland Rotation

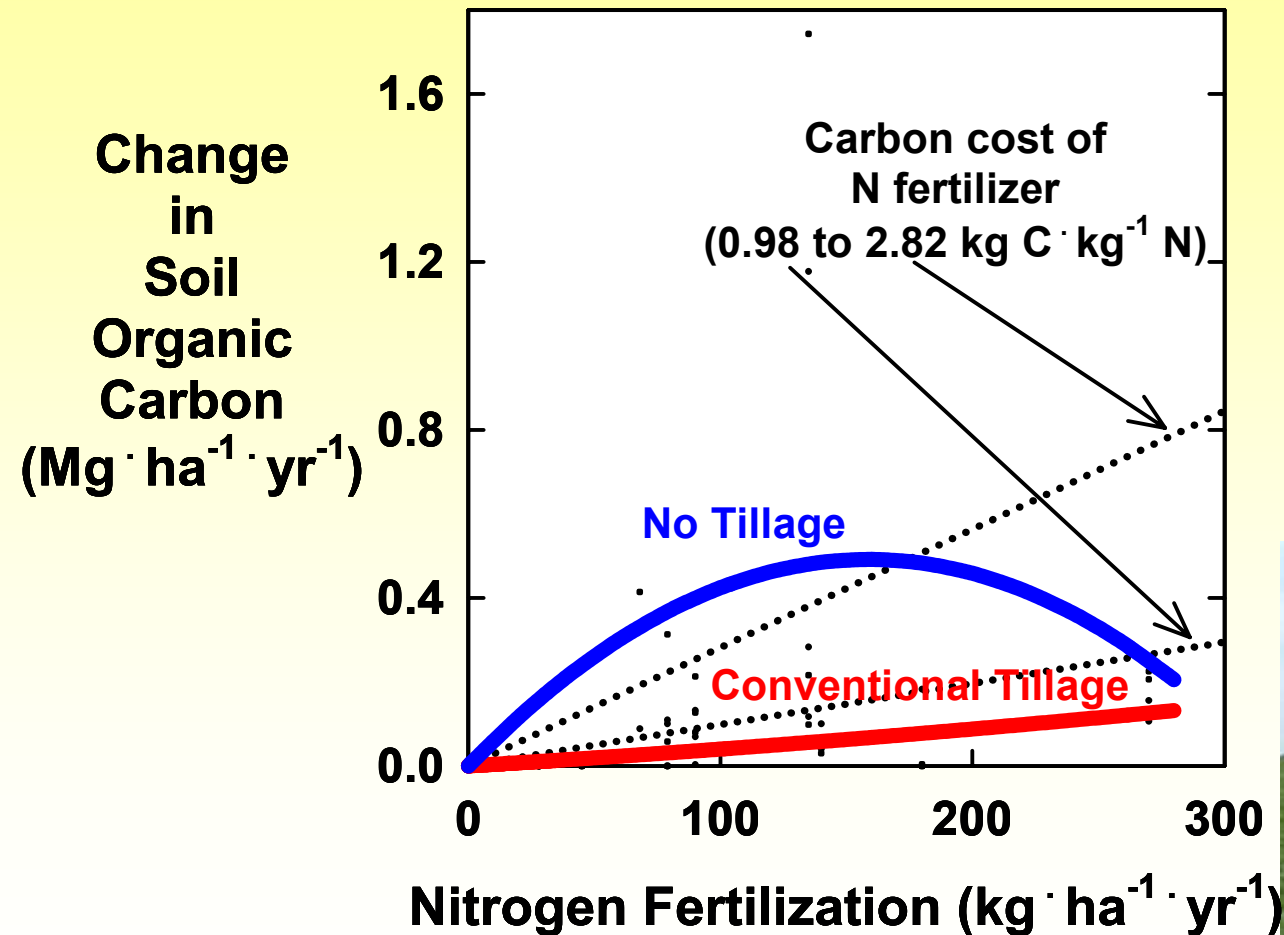
✓ Opportunities exist to capture more carbon from crop and grazing systems when the two systems are integrated:

- Utilization of ligno-cellulosic plant materials by ruminants
- Manure deposition directly on land
- Weeds can be managed with management rather than chemicals



Franzluebbers and Stuedemann (2008) Soil Sci. Soc. Am. J. 72:613-625

Optimal Fertilization



Therefore, soil carbon sequestration needs to be evaluated with a system-wide approach that includes all costs and benefits



Summary and Conclusions

- ✓ **Greenhouse gas concentrations in the atmosphere are increasing and the threat of global change requires our attention**
 - **Benefits from conservation agricultural systems can be reaped whether climate change is man-induced or not**
- ✓ **A diversity of conservation agricultural management practices can be employed to sequester more carbon in plants and soil**
 - **Syntheses of available data are needed**
 - **Gaps in our knowledge need to be researched**
- ✓ **Conservation strategies to sequester soil carbon will restore degraded land and avoid further degradation**